

**State of Missouri
Office of Administration
Division of Facility Management, Design and Construction**

Revised October 2009



**State of Missouri
Building Energy Efficiency Design
Standard
(BEEDS)**

EXECUTIVE ORDER 09-18

WHEREAS, in recognition of the importance of energy efficiency and the use of clean, domestic energy resources, and of the importance of the leadership role of state government; and

WHEREAS, the State of Missouri commits to managing operational costs and sustaining resources for future generations; and

WHEREAS, the prudent utilization of energy conservation is of prime importance for the continued economic and environmental progress of the State of Missouri; and

WHEREAS, the energy required for the operation of state government buildings is a significant portion of the energy consumption of Missouri State Government; and

WHEREAS, the reduction of energy use in state government buildings will result in cost savings and the preservation of valuable natural resources; and

WHEREAS, the State of Missouri has the duty and opportunity to moderate energy use.

NOW THEREFORE, I, JEREMIAH W. (JAY) NIXON, GOVERNOR OF THE STATE OF MISSOURI, by virtue of the authority vested in me by the Constitution and laws of the State of Missouri, do hereby order that all state agencies whose building management falls under the direction of the Office of Administration shall institute policies in consultation with the Division of Facilities Management, Design and Construction and the Department of Natural Resources' Energy Center that will result in reductions of energy consumption by two percent per year for each of the next 10 years.

All new state construction, buildings being constructed for lease by the state, and significant renovations and replacement of energy-using equipment shall be at least as stringent as the most recent energy efficiency standards of the International Energy Conservation Code (IECC). Exemptions shall be limited to those listed in the IECC and exemptions approved by the Director of Facilities Management, Design and Construction.

Energy efficiency shall be made a priority in design, construction and operation of state government buildings. The Office of Administration shall develop and adopt a State Building Energy Efficiency Design Standard that establishes and prioritizes energy efficient design techniques specific to the needs and operations of state facilities. The State Building Energy Efficiency Design Standard shall incorporate as goals the energy recommendations and practices presented in the American Society of Heating, Refrigerating and Air-Conditioning Engineers' (ASHRAE) Advanced Energy Design Guide for Small Office Buildings. The State Building Energy Efficiency Design Standard shall also be made available for adoption by other state agencies whose building management does not fall under the direction of the Office of Administration.

IN WITNESS WHEREOF, I have hereunto set my hand and caused to be affixed the Great Seal of the State of Missouri, in the City of Jefferson, on this 23rd day of April, 2009.

Jeremiah W. (Jay) Nixon
Governor
ATTEST:

Robin Carnahan
Secretary of State

Missouri Revised Statutes

Chapter 8

State Buildings and Lands

Section 8.812

August 28, 2008

Minimum energy efficiency standards for state buildings established by rule--compliance required--exemption, when.

8.812. 1. By January 1, 2009, the department shall establish, by rule, a minimum energy efficiency standard for construction of a state building over five thousand square feet, substantial renovation of a state building over five thousand square feet when major energy systems are involved or a building over five thousand square feet which the state or state agency considers for acquisition or lease. Such standard shall be at least as stringent as the International Energy Conservation Code 2006, or the latest version thereof.

2. All design which is initiated on or after July 1, 2009, for construction of a state building over five thousand square feet or substantial renovation of a state building over five thousand square feet when major energy systems are involved or any building over five thousand square feet which the state or state agency considers for acquisition or lease after July 1, 2009, shall meet applicable provisions of the minimum energy efficiency standard.

3. The commissioner of the office of administration may exempt any building from the requirements of subsection 2 of this section:

(1) When compliance with the minimum energy efficiency standard may compromise the safety of the building or any of its occupants; or

(2) When the cost of compliance is expected to exceed the projected energy cost savings gained.

(L. 1993 H.B. 195 § 4 subsecs. 3, 4, A.L. 2008 S.B. 1181, et al.)

Introduction

Developed by the Office of Administration (OA) / Division of Facility Management Design and Construction (FMDC) this document shall be known as the State of Missouri **Building Energy Efficiency Design Standard (BEEDS)**. The intent of this document is to assure that all new and renovated applicable building construction complies with the requirements of the Missouri Revised Statutes, Chapter 8 - State Buildings and Land, Section 8,812 and Executive Order 09-18.

FMDC feels it is during the project initiation, schematic and design development phases when large energy savings can be achieved with the least amount of efforts. To assure the greatest cost effective savings all major renovation projects affecting the building energy profile as well as all new building projects will require the design team to incorporate the services of an Energy Analyst.

By constructing and renovating buildings with energy efficiency in mind, FMDC can significantly reduce long-term operating costs and adverse environmental impacts associated with the generation of electrical power, burning of fossil fuels and release of green house gases. BEEDS emphasizes and establishes energy efficiency as a priority and an integral part of the design process for State Facilities. This document provides FMDC Staff, Design Team, and the Energy Analysts detailed information in establishing and prioritizing energy efficient design concepts and techniques.

BEEDS was developed around the recommendations and requirements of the International Energy Conservation Code (IECC), ASHRAE Energy Standard for Buildings Except Low-Rise Residential Buildings (ASHRAE 90.1) and the Federal Energy Management Program (FEMP) and specific revisions herein. BEEDS shall, regulate and govern the design, construction, maintenance and repair of building to be constructed, renovated, purchased, or leased for the purpose of conducting the business of the State of Missouri.

FMDC shall expend up to ten percent (10%) of the amount appropriated each year from the Facilities Maintenance Reserve Fund for maintenance, repair, or renovation projects that are otherwise allowable under the constitution but that are also considered energy projects with a fifteen year payback or less.

The Director of FMDC shall approve specific computer software, worksheets, compliance manuals, and other similar materials that meet the intent of this standard.

Project Determination and Notification Phase

BEEDS levels of compliance.

- Building Energy Efficiency Level 0 – No compliance required
- Building Energy Efficiency Level 1 – Equipment & Systems Compliance.
- Building Energy Efficiency Level 2 – BEED Baseline Building Compliance.
- Building Energy Efficiency Level 3 – BEED Baseline Building Compliance less 20%.

A BEED Baseline Building is a hypothetical building design based on incorporating the standard design features of typical buildings of the same usage and the minimum prescriptive requirements of the IECC and those contained in Appendix B of this document.

A BEED Compliant Building is a hypothetical building which incorporates the standard design features of typical buildings of the same usage and the minimum prescriptive requirements of the IECC and those contained in Appendix B of this document and EMC's to meet or the exceed the required Building Energy Efficiency Level as dictate by this standard.

New buildings in excess of five thousand (5,000) square feet and less than or equal to fifteen thousand (15,000) square feet shall comply with the Building Energy Efficiency Level – 2 requirements.

New buildings in excess of fifteen thousand (15,000) square feet shall exceed the minimum International Energy Conservation Code (IECC) requirements by 20% and shall comply with the Building Energy Efficiency Level – 3 requirements.

Building in excess of five thousand square feet (5,000) for which the extent of the renovation will affect at least fifty percent (50%) of the total square footage of the building or the costs of such modifications will equal or exceed fifty percent of the building's fair market value shall comply with the Building Energy Efficiency Level – 2 requirements.

Remodeled buildings which the scope of the changes has minimal affect on the energy profiles of the building shall comply with the Building Energy Efficiency Level – 0 requirements.

Additions or extensions to buildings that increase in the floor area or height of a building, outside of the existing building envelope shall be considered additions to existing buildings and shall comply with the Building Energy Efficiency Level – 2 requirements.

Portions of a building envelope systems, heating systems, ventilating systems , air conditioning systems, service water heating systems, power systems, lighting systems,

and other systems and equipment that are being replaced or upgraded shall be considered as Alterations of Existing Buildings and shall comply with the Building Energy Efficiency Level – 1 requirements.

Buildings undergoing a change in occupancy that would result in an increase in demand for either fossil fuel or electrical energy shall comply with the Building Energy Efficiency Level – 2 requirements.

Buildings or structures that are listed in the State of Missouri or National Register of Historic Places; designated as a historic property under local or state designation law or survey; certified as a contributing resource with a National Register listed or locally designated historic district; or with an opinion or certification that the property is eligible to be listed on the State of Missouri or National Register of historic places either individually or as a contributing building to a historic district by the State Historic Preservation Officer or Keeper of the National Register of Historic Places, shall comply with the Building Energy Efficiency Level – 0 requirements.

The Director of the FMDC shall determine on an individual basis the building energy efficiency level requirement for each project based on the criteria above. The building efficiency criteria have been summarized in the Building Energy Efficiency Level Determination Flow Chart in Appendix A. This flow chart shall be applied on a individual project basis and once the requirements have been the determined the Building Energy Efficiency Design Determination Form also included in Appendix A shall be completed and included in the project initiation documents.

Pre-Proposal Phase

When selecting a Design Firm, the request for proposal (RFP) shall include a reference to the BEED requirements.

The Design Firm shall design the new buildings to minimize long-term operation and maintenance costs. The Design Team will be responsible for providing a design that meets or exceeds the minimum requirements established by this standard. Cost effective energy conservation measures will be identified and to extent economically feasible incorporated in the building design.

Projects requiring Building Energy Efficiency Level 1 compliance, the design firm shall include services necessary to document energy savings resulting from the replacement of equipment and systems. This may include mechanical and electrical equipment and systems as well as, building envelope components.

Projects requiring Building Energy Efficiency Level 2 compliance, the Design Firm shall include services an Energy Analyst to simulate building energy requirements and energy costs.

Projects requiring Building Energy Efficiency Level 3 compliance, the Design Firm shall include an Energy Analyst to simulate building energy and energy costs, with the objective to exceed the Baseline Building requirements by 20%. ASHRAE 90.1 provides specific guidance on the rules and procedures and shall be used as means of determining the energy performance.

Design Firm shall for projects requiring an Energy Analyst (Level 2 and 3 compliance) complete and submit the Energy Analyst Qualification Form in Appendix A along with a list of energy efficient building projects, a list of technologies or design strategies routinely used, along with the maintenance requirements, a list of software tools, and energy methods and concepts for reducing energy use.

Design Programming Phase

In Projects requiring level 1 compliance the design firm shall list equipment and systems which will be replaced or affected. The new equipment and systems shall be selected to comply with the most stringent energy efficiency requirements as identified in the Equipment Efficiency Requirements in Appendix B, or the requirements contained in chapter 5 of the IECC, or the requirements of ASHRAE/IESNA Standard 90.1.

Projects requiring level 2 or 3 compliance, the Design Team shall during the programming phase complete the Building Interior Load Design Criteria Form, Building Design Criteria Form, and Preliminary Programming Considerations Checklist provided in Appendix C. Information contained in these forms and checklists can be collected and serve as a reference to what should be included in the programming document. This information needs to be documented so dialog about relevant ECM options can be more clearly defined.

Full development of these checklists will evolve as design progresses into schematic and design development phases. It may be necessary to defer decisions on particular efficiency concepts until the energy model is developed in order to address potential energy savings and cost effectiveness.

A list of energy programming and design intent items should be considered early in the design effort when basic building concepts are being developed. Integration of many of these design concepts is required early because adoption later in the design is often cost prohibitive or not feasible. Building operating hours, occupant comfort and sizing of energy using equipment, as well as other, operational requirements and design criteria have significant impact on building energy use and operational costs.

Schematic Design Phase:

In the schematic phase, projects requiring level 1 compliance the design team shall complete an energy cost savings analysis for all new applicable systems each piece of equipment and submit with the schematic design documents. The analysis should show the existing energy use of the equipment, the proposed energy use of the equipment, and the IECC minimum energy use of the equipment.

New buildings and major renovations which require level 2 or 3 compliance the design team and FMDC shall meet to further define the energy goals and the design criteria of the project. Working with the FMDC representative, the Design Team, and Energy Analyst shall complete the ECMs checklist in Appendix D. Completion of the ECM checklist should allow capture significant opportunities for building energy savings.

FMDC, the Design Team, and the Energy Analyst shall select the ECMs for analysis. The energy analyst shall provide a detailed approach and tools which will be used during the modeling process.

Design Development Phase

No further requirement of level 1 compliance project is necessary unless a life cycle cost is warranted.

Selection of chiller types in new buildings shall be based on the project requirements, and budget. Bidding and award of standard chillers exceeding 150 tons from qualified manufacturer in new buildings shall be based upon the lowest life cycle cost. The LCC shall be incorporated in the bid documents.

Chiller performance and subsequent energy use shall be determined using either full-load efficiency (EER) or integrated part-load efficiency (IPLV) depending upon the application. Integrated part-loads (IPLV) shall be used for variable loads accompanying variable ambient temperatures and humidity levels. Energy Efficiency Ratios shall be used where chiller load is high and ambient temperatures and humidity levels are relatively constant (e.g., for baseline chillers) and the load profile can be documented. Chillers selected for non-standard operating conditions shall be based on non-standard part-load value (NPLV), which maintains the same weightings.

Where the actual chiller load profile is known it can be substituted to determine the chiller's performance and energy use.

The Energy Analyst shall use the Building Modeling for Baseline Building analysis and individual ECMs analysis for projects requiring level 2 or 3 compliance. Baseline Building is a hypothetical building design based on incorporating the standard design features of typical buildings of the same usage and to just meet the prescriptive requirements of the IECC and Appendix B of this document.

The Energy Analyst may use fully document manual calculations for simple, non-interactive ECMs and may eliminate potential ECMs with preliminary estimates of costs and savings if the Simple Payback is greater than the equipment life.

The Energy Analyst and the Design Team shall review the Preliminary Energy Analysis Report and provide its written or verbal comments and recommendations to Design Team prior to the ECM Review Meeting.

The Energy Analyst completes the preliminary energy analysis before the ECM review meeting. The preliminary energy analysis includes the Baseline Building analysis, and the Compliant Building Analysis, individual ECM analysis, and preliminary interactive package analysis:

- Complete the model of the Baseline Building using approved modeling programs. The Baseline Building model includes Baseline ECMs not requiring analysis.
- Review the Baseline Building model end-use energy breakdown and total energy use. Compare the results to average energy use index for that type of building.

- Analyze energy use of ECMs individually using the Baseline model as the benchmark to determine energy savings. All manual calculations shall be fully documented.
- Complete cost estimates and ECM cost-effectiveness analysis. ECMs are considered cost effective when the net present value (NPV) of savings is positive and the benefit-to-cost ratio (BCR) is greater than one (1.0).
- Rank the cost-effective measures based on their NPV. If ECMs are mutually exclusive, select the ECM with the higher NPV savings unless there are overriding aesthetic, functional, reliability, maintenance, or programmatic reasons to select an ECM that has a lower NPV. An ECM with a lower NPV also could be selected if the higher NPV alternative is not as cost-effective when analyzed in an ECM package.
- Complete an interactive building model containing a package of all ECMs with a BCR greater than 1 and determine the package BCR and NPV. A second interactive model may be necessary only if there are two or more ECMs that are mutually exclusive (e.g., two different kinds of heat recovery systems). In that case, select the ECM package with the highest BCR.
- Determine the percent energy savings of the Compliant Building using the Baseline Building as the benchmark. If the Compliant Building does not meet the requirement of using 20% less energy than the Code Building do the following:
- Select an alternative ECM package with a BCR greater than 1 that meets the minimum 20% better than code requirement.
 - Add to the Compliant Building model one ECM (or a group of similarly ranked ECMs) with the highest BCR of the ECMs not yet in the package. Repeat this procedure until the Compliant Building meets the 20% requirement, the benefit to cost ratio of the selected package is less than one, or all reasonable analyzed measures have been added.
 - If the SEED Building still does not meet the 20% better than code requirement, reevaluate the ECM identification list for inclusion of ECMs not originally selected for analysis. This will require consultation with the design team, the FMDC. Include these ECMs in the Complaint Building Model as necessary to meet the 20% better than code requirement.

Preliminary Energy Analysis Report shall include:

- A copy of the ECM Checklist with notations for baseline and suggested ECMs.
- Narrative describing the proposed Baseline Building and the Compliance Building.
- List of all ECMs, and the recommended ECM package.
- Preliminary ECM calculations, estimates, and justification for eliminated ECMs.
- Preliminary ECM Analysis worksheets for both recommended and eliminated ECMs.
- Cost-Effectiveness Analysis worksheets
- Electronic version of the building model inputs.

- A list of modeling inputs and values that have been changed for each building model.
- Summary output report(s) for the Compliant Building, the Proposed Baseline Building.
- A breakdown of energy usage at minimum for the following components: lights, internal equipment loads, service water heating equipment, space heating equipment, space cooling and heat rejection equipment, fans, and other HVAC equipment (such as pumps).
- The amount of time any loads are not met by the HVAC system for both the proposed design and baseline building design.
- An explanation of any warning messages noted in the simulation program output.
- Electronic copies of complete model outputs are required.
- Current energy rate schedules. Where energy is received from a state-operated central plant, cite the rate source used.
- Manual savings calculations if any.
- Building-model HVAC zone map.
- Miscellaneous information: equipment catalog sheets, test reports, etc.
- Modeled energy use of compliant and baseline building showing electrical and fossil fuel use on a monthly basis.
- Building metering plan
- Performance Verification Plan

Final Energy Analysis Report:

The Energy Analyst completes the final energy analysis after the ECM review meeting. The final energy analysis includes the final ECM package analysis:

- Adjust individual ECM, Baseline Building analysis, or Compliant Building analysis, if required, based on feedback and changes at the ECM review meeting.
- Eliminate ECMs determined to be inappropriate or impractical at the ECM review meeting. Document reasons for their elimination.
- Complete the analysis of the final selected interactive package to include in the Compliant Building.
- Refine cost estimates for ECMs to be included in the Compliant Building. Make any other necessary adjustments to the ECM cost-effectiveness analysis.
- Provide a professional sealed letter with the final report stating the proposed design meets or exceeds the Building Energy Efficiency Level established for the project.

Economic Analysis

Life-Cycle Cost Analysis

A Life Cycle Cost Analysis shall be used to evaluate building design alternatives that have different initial investment costs, different operating costs, maintenance requirements, and repair (OM&R) costs, as well as, different lives; which satisfy the required level of building performance - including occupant comfort, safety, adherence to building codes and engineering standards, system reliability, and aesthetics.

The LCC methodology and criteria shall be as established by the National Institute of Standards and Technology Handbook 135 “Life-Cycle Costing Manual” (NIST 135) (<http://www.bfrl.nist.gov/oae/publications/handbooks/135.pdf>) for the Federal Energy Management Program.

The Energy Price Indices, and Discount Factors for determining the Uniform Present Value (UPV) factors is available (<http://www1.eere.energy.gov/femp/pdfs/ashb08.pdf>).

Simplified Life-Cycle Cost Analysis

Selection for replacement chillers types (package air cooled, remote air cooled, water cooled, etc.) shall be made to match the existing. Procurement of replacement chillers shall be based on a simplified life cycle cost analysis.

Simplified life-cycle cost (LCC) analysis, this annual energy cost should be multiplied by the regional electricity Uniform Present Value (UPV) factor for the estimated lifetime of the equipment; and then added to the initial cost of the chiller (or present value of the chiller's financed cost):

$$\text{Simplified Life Cycle Cost} = (\text{Annual Energy Cost} * \text{Uniform Present Value Factor}) + \text{Initial Cost}$$

The basic formula for estimating annual energy use multiplies the average system load (in tons) by the relevant efficiency (Full-Load or IPLV) by the annual number of equivalent full- or part-load operating hours. The resultant annual kWh figure can then be multiplied by the average cost per kWh for electricity, yielding the annual energy cost:

Payback

When computing the payback - Discounted Payback (DPB) method shall be used for project alternatives relative to an identified base case.

APPENDIX A

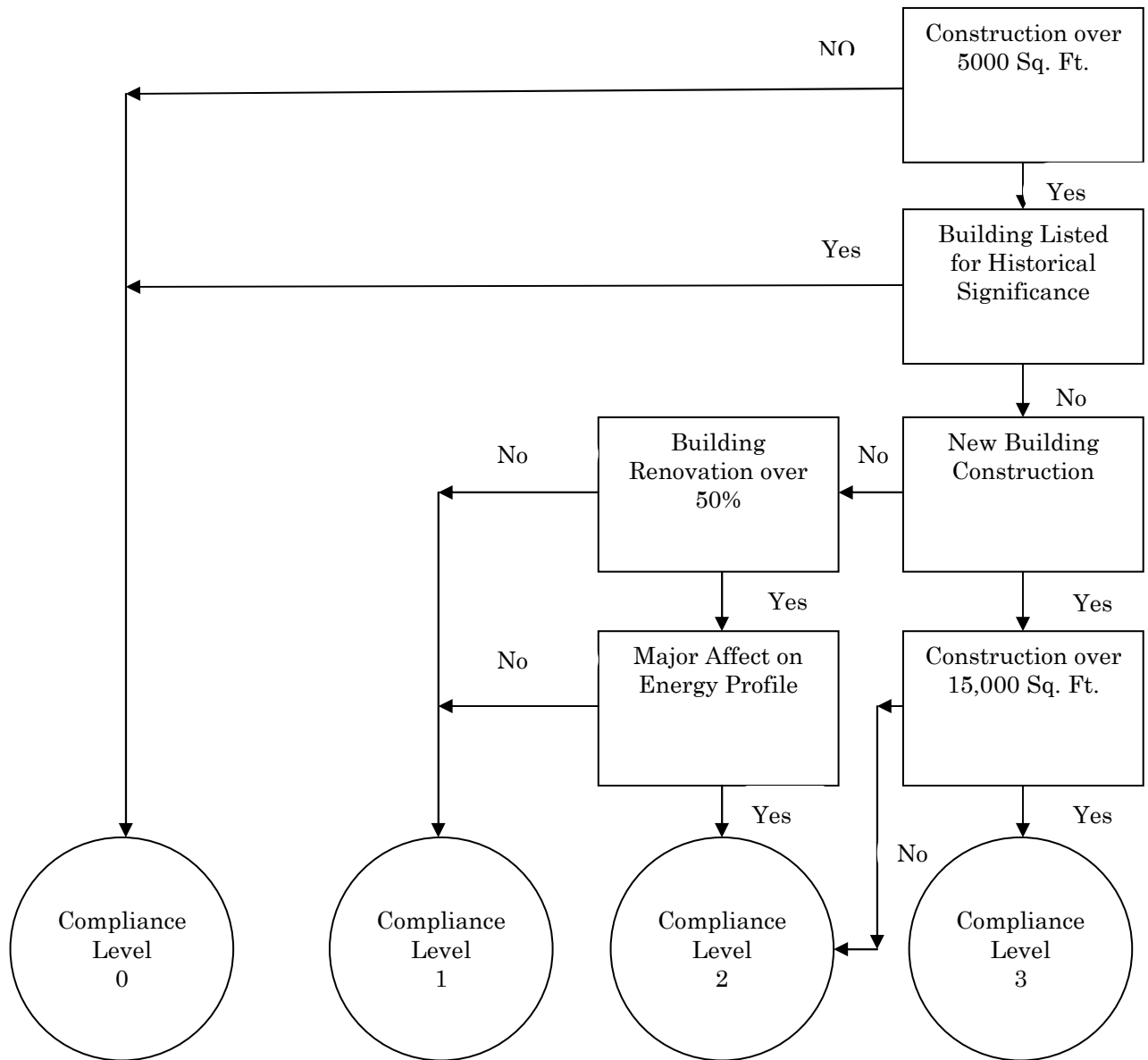
State of Missouri Building Energy Efficiency Level Compliance Chart

Compliance Level 0 – None

Compliance Level 1 – Equipment & Systems

Compliance Level 2 – BEED Baseline Building

Compliance Level 3 – BEED Baseline Building less 20%.





STATE OF MISSOURI
OFFICE OF ADMINISTRATION
DIVISION OF FACILITIES MANAGEMENT, DESIGN AND
CONSTRUCTION
**BUILDING ENERGY EFFICIENCY DESIGN
DETERMINATION FORM**

PROJECT NUMBER

Date

Project Name:

Project Manager:

Facility:

Project Description:

Energy systems affected:

Area and Use Information:

Project type: Historic New Construction Renovation

Total floor area heated (sq. ft.)
Total floor area cooled (sq. ft.)
Affected floor area (sq.ft.)
Construction cost

Comments

**Compliance
Requirement**

0 1 2 3

Section Leader

DATE

Signature:

Energy Analyst Qualifications Form

Energy Analyst's Name:

List the qualifications of the person(s) responsible for the accuracy of the energy model and the Energy Analysis Report:

Description of experience with a computerized, hourly building modeling tool for energy analysis.

How current is this experience?

List computer modeling programs with which the modeler has experience including years of experience with each modeling program:

Provide reference contacts for energy modeling experience:

List name(s) of others who will be working on the model and report:

List projects on which the Energy Analyst has performed computer modeling:

Attach a sample of Energy Analysis Reports:

List any buildings modeled for the SEED program:

Number of years of full time energy modeling experience:

Has the Energy Analyst taken the ODOE Energy Modeling Workshop?
Date of Workshop

APPENDIX B

Energy-Efficient Commercial Unitary Air Conditioner

EER (energy efficiency ratio) is the cooling capacity (in Btu/hour) of the unit divided by its electrical input (in watts) at the Air Conditioning and Refrigeration Institute's (ARI) standard peak rating condition of 95°F.

SEER (seasonal energy efficiency ratio) and IPLV (integrated part-load value) are similar to EER but weigh performance at different (peak and off-peak) conditions during the cooling season.

Equipment Type	Size Category	Minimum Efficiency
Air Conditioners, Air Cooled (Single-packaged or split systems)	<65,000 Btu/h	12.0 SEER
	≥65,000 Btu/h and <135,000 Btu /h	11.0 EER 11.4 IPLV
	≥135,000 Btu/h and <240,000 Btu /h	10.8 EER 11.2 IPLV
	≥240,000 Btu/h and <760,000 Btu/h	10.0 EER 11.0 IPLV
	≥760,000 Btu/h	10.0 EER 11.0 IPLV
Through-the-Wall, Air Cooled	≤ 30,000 Btu/h	11.0 SEER
Air Conditioners, Water Cooled (Single-packaged or split systems)	<65,000 Btu/h	12.1 SEER
	≥65,000 Btu/h and <135,000 Btu/h	11.3 EER 11.5 IPLV
	≥135,000 Btu/h and <240,000 Btu/h	11.0 EER 11.0 IPLV
	≥240,000 Btu/h	11.0 EER 11.0 IPLV

Energy-Efficient Air-Cooled Chiller

Values are based on standard rating conditions specified in ARI Standard 550/590-98. Only packaged chillers (i.e., none with remote condensers) are covered. Integrated part-load value (IPLV) is a weighted average of efficiency measurements at various part-load conditions, as described in ARI Standard 550/590-98.

Equipment Type	Capacity	Part Load Optimized Chillers Minimum Efficiency
Air Cooled, with Condenser	<150 Tons	2.80 COP (1.25 KW/Ton) 3.50 IPLV (1.0 KW/Ton)
Air Cooled, without Condenser	<150 Tons	3.10 COP (1.13 W/Ton) 3.50 IPLV (1.0 KW/Ton)
Water Cooled, Electrically Operated, Reciprocating	<150 Tons	4.20 COP (0.84 W/Ton) 5.05 IPLV (0.70 KW/Ton)
Water Cooled, Electrically Operated, Rotary Screw and Scroll	<150 Tons	4.45 COP (0.79 W/Ton) 5.20 IPLV (0.68 KW/Ton)
Water Cooled, Electrically Operated, Rotary Screw and Scroll	<150 Tons	4.45 COP (0.79 W/Ton) 5.20 IPLV (0.68 KW/Ton)
Water Cooled, Electrically Operated, Centrifugal	<150 Tons	5.00 COP (0.70 W/Ton) 5.25 IPLV (0.67 KW/Ton)

Energy-Efficient Water-Cooled Chiller

Values are based on standard reference conditions specified in ARI standard 550/590-98. Integrated part load value (IPLV) is a weighted average of efficiency measurements at various part-load conditions, as described in ARI Standard 550/590-98. Full load efficiency is measured at peak load conditions described in ARI Standard 550/590-98.

Compressor Type and Capacity	Part Load Optimized Chillers
	IPLV (kW/ton)
Centrifugal (150 - 299 tons)	0.52 or less
Centrifugal (300 - 2,000 tons)	0.45 or less
Rotary Screw >= 150 tons	0.49 or less
Compressor Type and Capacity	Full Load Optimized Chillers
	Full Load (kW/ton)
Centrifugal (150 - 299 tons)	0.59 or less
Centrifugal (300 - 2,000 tons)	0.56 or less
Rotary Screw >= 150 tons	0.64 or less

Packaged Terminal Air Conditioners and Heat Pumps

Efficiency levels for air-source units sized between 65 and 240 MBtu/h meet ASHRAE 90.1 minimum efficiency requirements. The best available EER and best available COP apply to different models. Only units with 3-phase power supply are covered in this category.

Water source heat pumps covered here use cooling towers and boilers as the heat transfer sink or source in a closed loop piping system. This may increase boiler energy use by lowering the return water temperature. Auxiliary pumping energy is not included in the WSHP efficiency rating.

COP (Coefficient of Performance) is the heating capacity (in Btu/h) at standard heating conditions divided by its electrical input (also in Btu/h). HSPF (Heating Seasonal Performance Factor), like SEER, weighs heating performance at various conditions.

Equipment Type	Size Category	Ratings	Minimum Efficiency
Air Cooled (Single-packaged or split systems)	<65,000 Btu/h		12.0 SEER 7.7 HSPF
	≥65,000 Btu/h and <135,000 MBtu/h		10.0 EER/11.0 IPLV 3.2 /2.2 COP
	≥135,000 Btu/h and <240,000 MBtu/h		9.3 EER/10.0 IPLV 3.1/3.0 COP
	≥240,000 Btu/h		9.0 EER/9.2 IPLV 3.1/3.0 COP
Through-the-Wall, Air Cooled	≤ 30,000 Btu/h		10.6 SEER 7.0 HSPF
Water-Source,	<17,000 Btu/h	86F Entering Water	11.2 EER 4.2 COP
	≥17,000 Btu/h and <135,000 MBtu/h	86F Entering Water 68F	12.8 EER 4.5 COP
Ground-Source,	<135,000 Btu/h	59F Open 77F Closed	16.2 EER 14.1 COP
	≥17,000 Btu/h and <135,000 MBtu/h	86F Entering Water 68F	12.0 EER 4.2 COP

Energy-Efficient Distribution Transformer

Energy efficiency of distribution transformers is defined by NEMA's *Standard Publication TP-1* as output kVA divided by the sum of output kVA plus losses, at a specified percent load and reference temperature.

Low voltage transformers have a primary voltage of 1200 volts or less; efficiency is measured at 35% of nameplate load, at 75°C. Medium voltage transformers have a primary voltage greater than 1200 volts; efficiency is measured at 50% of nameplate load, at 75°C for dry-type transformers and 85°C for liquid-filled.

Rated Capacity (kVA)	Low Voltage	Medium Voltage	
	Recommended Level	Recommended Level (Dry)	Recommended Level (Liquid)
10	—	—	98.3 or more
15	97.7 or more	97.6 or more	98.5 or more
25	98.0 or more	97.9 or more	98.7 or more
37.5	98.2 or more	98.1 or more	98.8 or more
50	98.3 or more	98.2 or more	98.9 or more
75	98.5 or more	98.4 or more	99.0 or more
100	98.6 or more	98.5 or more	99.0 or more
167	98.7 or more	98.7 or more	99.1 or more
250	98.8 or more	98.8 or more	99.2 or more
333	98.9 or more	98.9 or more	99.2 or more
500	—	99.0 or more	99.3 or more
667	—	99.0 or more	99.4 or more
833	—	99.1 or more	99.4 or more
Three Phase Percent Efficiency			
15	97.0 or more	96.8 or more	98.0 or more
30	97.5 or more	97.3 or more	98.3 or more
45	97.7 or more	97.6 or more	98.5 or more
75	98.0 or more	97.9 or more	98.7 or more
112.5	98.2 or more	98.1 or more	98.8 or more
150	98.3 or more	98.2 or more	98.9 or more
225	98.5 or more	98.4 or more	99.0 or more
300	98.6 or more	98.5 or more	99.0 or more
500	98.7 or more	98.7 or more	99.1 or more
750	98.8 or more	98.8 or more	99.2 or more
1000	98.9 or more	98.9 or more	99.2 or more
1500	—	99.0 or more	99.3 or more
2000	—	99.0 or more	99.4 or more
2500	—	99.1 or more	99.4 or more

Electric Motors

Motors that meet the required efficiency levels carry the NEMA Premium™ label, a program sponsored by the National Electrical Manufacturers Association (NEMA) and endorsed by the Consortium for Energy Efficiency.

Variable frequency drives (VFDs), the shall be installed with motors of 10 HP or greater which service a variable load.

Nominal Efficiencies for Induction Motors Rated 600 Volts or Less (Random Wound)						
Mot or Size (HP)	Open Drip-Proof (ODP)			Totally Enclosed Fan-Cooled (TEFC)		
	6-pole (1200 rpm)	4-pole (1800 rpm)	2-pole (3600 rpm)	6-pole (1200 rpm)	4-pole (1800 rpm)	2-pole (3600 rpm)
1	82.5	85.5	77.0	82.5	85.5	77.0
1.5	86.5	86.5	84.0	87.5	86.5	84.0
2	87.5	86.5	85.5	88.5	86.5	85.5
3	88.5	89.5	85.5	89.5	89.5	86.5
5	89.5	89.5	86.5	89.5	89.5	88.5
7.5	90.2	91.0	88.5	91.0	91.7	89.5
10	91.7	91.7	89.5	91.0	91.7	90.2
15	91.7	93.0	90.2	91.7	92.4	91.0
20	92.4	93.0	91.0	91.7	93.0	91.0
25	93.0	93.6	91.7	93.0	93.6	91.7
30	93.6	94.1	91.7	93.0	93.6	91.7
40	94.1	94.1	92.4	94.1	94.1	92.4
50	94.1	94.5	93.0	94.1	94.5	93.0
60	94.5	95.0	93.6	94.5	95.0	93.6
75	94.5	95.0	93.6	94.5	95.4	93.6
100	95.0	95.4	93.6	95.0	95.4	94.1
125	95.0	95.4	94.1	95.0	95.4	95.0
150	95.4	95.8	94.1	95.8	95.8	95.0
200	95.4	95.8	95.0	95.8	96.2	95.4
250	95.4	95.8	95.0	95.8	96.2	95.8
300	95.4	95.8	95.4	95.8	96.2	95.8
350	95.4	95.8	95.4	95.8	96.2	95.8
400	95.8	95.8	95.8	95.8	96.2	95.8
450	96.2	96.2	95.8	95.8	96.2	95.8
500	96.2	96.2	95.8	95.8	96.2	95.8
Nominal Efficiencies for Induction Motors Rated Medium Voltage - 5 kV or less (Form Wound)						

250 - 500	95.0	95.0	94.5	95.0	95.0	95.0
-----------------	------	------	------	------	------	------

Energy-Efficient Fluorescent Tube Lamps

Lamp Type	Light Output
T8, 32 watts	2800 lumens or more
T12, 34 watts	2800 lumens or more
T8,59 watts	5700 lumens or more
T12,34 watts	2800 lumens or more
T8,59 watts	5700 lumens or more
T12,60 watts	5600 lumens or more
T8/U,31-32 watts	2600 lumens or more
T12/U,34 watts	2700 lumens or more

Energy-Efficient Fluorescent Tube Lamps

Lamp Type	# of Lamps	Ballast Efficacy Factor
Four-Foot and U-Tube Lamps		
T8,32 Watts	1	2.54 or higher
	2	1.44 or higher
	3	0.93 or higher
	4	0.73 or higher
T12,34 Watts	1	2.64 or higher
	2	1.41 or higher
	3	0.93 or higher
Eight-Foot Lamps		
T8,59 Watts	2	0.80 or higher
T12,60 Watts	2	0.80 or higher

Lighting Control Requirements

Type of Control	Private Office	Open Office - Daylight	Open Office - Interior
Occupancy Sensors	Required	Required	Required
Time Scheduling		Required	Required
Daylight Dimming	Required	Required	
Bi-Level Switching	Required		
Demand Lighting		Required	Required

Energy-Efficient Commercial Kitchen Equipment:

Refrigerator and Freezer

When buying a commercial solid door refrigerator choose a model that meets or exceeds ENERGY STAR[®], all of which meet this recommendation. If a product is not labeled ENERGY STAR[®], use the formula from the table to determine if it meets the efficiency recommendation.

Product Type	Daily Energy Consumption
Refrigerator	$0.10V + 2.04 \text{ kWh/day or less}$
Refrigerator-Freezer	$0.27AV - 0.71 \text{ kWh/day or less}$
Freezer	$0.40V + 1.38 \text{ kWh/day or less}$
Ice Cream Freezer	$0.39V + 0.82 \text{ kWh/day or less}$

Based on ASHRAE *Standard Test Method 117-1992 Method of Testing Closed Refrigerators*. Use the formula above to calculate the recommended daily energy consumption. "V" represents the volume of a commercial refrigerator in cubic feet. For dual temp models, "AV" represents the adjusted volume, which is the refrigerator volume plus 1.63 multiplied by the freezer volume in cubic feet.

Electric and Gas griddles.

Commercial griddles shall be selected that meet the *Performance Requirements* shown above.

Steamer Type and Capacity	Cooking Energy Efficiency	Idle Energy Rate
Gas, 2 foot	38% or greater	11,000 Btu/hour or less
Gas, 3 foot	38% or greater	16,000 Btu/hour or less
Gas, 4 foot	38% or greater	21,000 Btu/hour or less
Gas, 5 foot	38% or greater	26,000 Btu/hour or less
Gas, 6 foot	38% or greater	31,000 Btu/hour or less
Electric, 2 foot	70% or greater	1,500 watts or less
Electric, 3 foot	70% or greater	2,300 watts or less
Electric, 4 foot	70% or greater	3,100 watts or less
Electric, 5 foot	70% or greater	3,800 watts or less
Electric, 6 foot	70% or greater	4,600 watts or less

Fryers

Cooking energy efficiency is defined as the ratio of the energy absorbed by the food to the total energy input to the fryer. Based on the heavy-load efficiency test as prescribed by ASTM Standard Test Method for the Performance of Open Deep-Fat Fryers (F1361).

Idle energy rate is the amount of energy an appliance uses to maintain a stabilized operating temperature.

Fryer Type	Cooking Energy Efficiency	Idle Energy Rate
Gas	50% or greater	9,000 Btu/hour or less
Electric	80% or greater	1,000 watts or less

Hot Food Holding Cabinets

Based on an idle energy rate of 40 watts/cubic foot. To determine the Energy Usage for sizes not shown, multiply the cabinet's internal volume (in cu. ft.) by 40.

The maximum idle energy rate is based on the "idle energy rate—dry test" in ASTM F2140-01. Interior volume (ft³) of each qualifying model must be measured according to the protocol provided below.

Measuring Interior Volume: Commercial hot food holding cabinet interior volume shall be calculated using straight-line segments following the gross interior dimensions of the appliance and using the following equation: interior height x interior width x interior depth. Interior volume shall not account for racks, air plenums or other interior parts.

Internal Volume	Energy Usage
Full Size (> 16 cu. ft.)	720 watts or less
Three-Quarter Size (10 to 16 cu. ft.)	400 watts or less
Half Size (< 10 cu. ft.)	300 watts or less

Commercial Steam Cookers

Provide commercial steam cookers that earn the ENERGY STAR and meet the ENERGY STAR specifications for energy efficiency as outlined below.

Cooking Energy Efficiency is based on heavy load (potato) cooking capacity. Idle Energy Rate: The rate of appliance energy consumption while it is maintaining or holding at a stabilized operating condition or temperature.

Energy Efficiency Requirements for Electric Steam Cookers		
Pan Capacity	Cooking Energy Efficiency	Idle Rate (watts)
3-pan	50%	400
4-pan	50%	530
5-pan	50%	670
6-pan	50%	800

*Cooking Energy Efficiency is based on heavy load (potato) cooking capacity.

Energy Efficiency Requirements for Gas Steam Cookers		
Pan Capacity	Cooking Energy Efficiency	Idle Rate (Btu/h)
3-pan	38%	6,250
4-pan	38%	8,350
5-pan	38%	10,400
6-pan	38%	12,500

Commercial Dishwashers

Provide commercial dishwashers that earn the ENERGY STAR and meet the ENERGY STAR specifications for energy and water efficiency as outlined below.

Idle energy rate as measured with door closed and rounded to 2 significant digits.
Includes pot, pan, and utensil machines.

Machine Type	High Temp Efficiency Requirements		Low Temp Efficiency Requirements	
	Idle Energy Rate *	Water Consumption	Idle Energy Rate *	Water Consumption
Under Counter	≤ 0.90 kW	≤ 1.00 gal/rack	≤ 0.5 kW	≤ 1.70 gal/rack
Stationary Single Tank Door**	≤ 1.0 kW	≤ 0.950 gal/rack	≤ 0.6 kW	≤ 1.18 gal/rack
Single Tank Conveyor	≤ 2.0 kW	≤ 0.700 gal/rack	≤ 1.6 kW	≤ 0.790 gal/rack
Multiple Tank Conveyor	≤ 2.6 kW	≤ 0.540 gal/rack	≤ 2.0 kW	≤ 0.540 gal/rack

Commercial Ice Machines

Provide commercial ice machines that earn the ENERGY STAR and meet the ENERGY STAR specifications for energy and water efficiency as outlined below.

Condenser Type	Ice Harvest Rate (lbs./24 hours)	Energy Consumption (per 100 lbs.of ice)
Ice-Making Head		
Air-Cooled	101 to 200	9.4 kWh or less
Air-Cooled	201 to 300	8.5 kWh or less
Air-Cooled	301 to 400	7.2 kWh or less
Air-Cooled	401 to 500	6.1 kWh or less
Air-Cooled	501 to 1,000	5.8 kWh or less
Air-Cooled	1,001 to 1,500	5.5 kWh or less
Water-Cooled	201 to 300	6.7 kWh or less
Water-Cooled	301 to 500	5.5 kWh or less
Water-Cooled	501 to 1,000	4.6 kWh or less
Water-Cooled	1,001 to 1,500	4.3 kWh or less
Water-Cooled	1,501 or more	4.0 kWh or less
Self-Contained		
Air-Cooled	101 to 200	9.7 kWh or less
Water-Cooled	201 to 300	6.8 kWh or less
Water-Cooled	301 to 400	7.3 kWh or less
Remote Condensing		
Air-Cooled	301 to 400	7.9 kWh or less
Air-Cooled	401 to 500	6.1 kWh or less
Air-Cooled	501 to 1,000	5.4 kWh or less
Air-Cooled	1,001 to 1,500	4.5 kWh or less
Air-Cooled	1,501 or more	4.4 kWh or less

Vending Machines

Provide vending machines that earn the ENERGY STAR and meet the ENERGY STAR specifications for energy efficiency as outlined below.

Low Power Mode: In addition to meeting the 24-hour energy consumption requirements listed below, qualifying models shall come equipped with hard wired controls and/or software capable of automatically placing the machine into a low power mode during periods of extended inactivity while still connected to its power source to facilitate the saving of additional energy, where appropriate. The machine shall be capable of operating in each of the low power mode states described below:

1. Lighting low power state – lights off for an extended period of time.
2. Refrigeration low power state – the average beverage temperature is allowed to rise above 40°F for an extended period of time.
3. Whole machine low power state – the lights are off and the refrigeration operates in its low power state.

In addition, the machine shall be capable of automatically returning itself back to its normal operating conditions at the conclusion of the inactivity period. The low power mode-related controls/software shall be capable of on-site adjustments by the vending operator or machine owner.

Low power mode requirements are to ensure that existing machine software capabilities are available and may be used to their fullest potential based on the individual requirements of the host site.

Machines that are vending temperature sensitive product, such as milk, must not have the refrigeration low power state enabled on site by the vending operator or machine owner due to the risk of product spoilage.

$$Y = 0.45 [8.66 + (0.009 \times C)]$$

Y = 24 hr energy consumption (kWh/day) after the machine has stabilized

C = vendible capacity

APPENDIX C

Building Design Criteria

Project name: _____

Programming Team shall complete this document (as much as possible) for use as a basis of discussion during the initial meeting.

The completed form shall be submitted one week before the Early Planning Session.

Space Name or Description	Area Sqft	Peak Number of Occupants	Average Number of Occupants	Occupancy Hours per Weekday/ Weekend	Occupancy Weeks per Year	Target Ambient Illumination, Footcandles	Target Task Illumination, Footcandles	Mechanical Cooling Desired?	Natural Ventilation Desired?

Building Interior Load Design Criteria

Project name:_____

Programming Team shall complete this document (as much as possible) for use as a basis of discussion during the initial meeting.

Space Name or	Area	Ventilation	Ventilation	Office	Process	Lighting	Infiltration	Desired	Desired
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The completed form shall be submitted one week before the Early Planning Session.

Description	Sqft	Occupancy Sqft / Person Or CFM / person	Rate CFM / Person	Equipment Watts / Sqft	Equipment Watts / Sqft	Power Density Watts/ Sqft	Air Changes Per Hour (ACH)	Cooling Temperature Occ/Unocc	Heating Temperature Occ/Unocc

PRILIMINARY PROGRAMMING CONSIDERATIONS

Project Name:		Project Number:
Fuels and Utilities:		
Service	Selection	Name of Utility
Electric		
Natural Gas		
Propane		
Fuel Oil		
Steam		
Other		
Electrical Service Voltage:		Primary
		Secondary
Points of Service:		Centralized
		Distributed
Back-Up Systems:		Electrical Stand-by Generator
		Support Systems for Consideration
		Fire Systems
		HVAC
		Computers
		Elevators
		Special Use Equipment
		Secondary and Alternative Fuels
		Support Systems for Consideration
		Heating
		Domestic Hot Water
		Special Use Equipment
Comment:		

PRILIMINARY PROGRAMMING CONSIDERATIONS

Project Name:		Project Number:	
Building Envelope			
	Building Orientation and Shape		
	East-West Axis		<input type="checkbox"/>
	Shape		<input type="checkbox"/>
	Enhance Wall Thermal Mass		
	Reduction of peak heating and cooling loads		<input type="checkbox"/>
	Reduction of energy use due to thermal flywheel effect		<input type="checkbox"/>
	Daylighting Architectural Features		
	Shading and Overhangs		<input type="checkbox"/>
	Light Shelves, Clerestories, Skylights		<input type="checkbox"/>
	Heat Absorption Prevention		
	Color selection of roof and wall surfaces		<input type="checkbox"/>
	Landscaping shading		<input type="checkbox"/>
Domestic Hot Water			
	Showers: Number of people and use pattern (described below)		
	Fixtures: Number and diversity factors (described below)		
	Special Equipment: (described below)		
	Fixture Controls		
	Manual		<input type="checkbox"/>
	Spring Returns		<input type="checkbox"/>
	Infra-red sensors		<input type="checkbox"/>
	Domestic Hot Water generation and distribution		<input type="checkbox"/>
Comments			

PRILIMINARY PROGRAMMING CONSIDERATIONS

Project Name:			Project Number:	
Equipment Loads				
	Office Equipment			
		Owner supplied electronic office equipment		<input type="checkbox"/>
		Sleep Mode, Energy Star or other standars		<input type="checkbox"/>
		Enhance Wall Thermal Mass		
		Occupancy based controls		<input type="checkbox"/>
		After hours switchable loads		<input type="checkbox"/>
	Large equipment or system loads			
		Space heat		<input type="checkbox"/>
		Domestic water heaters		<input type="checkbox"/>
		Food service equipment		
		Grilles, fryers, steam kittles, etc.		<input type="checkbox"/>
		Dishwasher, booster heaters, etc.		<input type="checkbox"/>
		Laboratory Equipment		
		Autoclaves		<input type="checkbox"/>
		Generators, hoods		<input type="checkbox"/>
	Others			
Comments				
Lighting Loads				
	Task lighting, lower ambient light levels			<input type="checkbox"/>
	Light colored interior finishes for wall, partitions and furniture			<input type="checkbox"/>
	Interior and exterior light sources			<input type="checkbox"/>
	Fixture types			<input type="checkbox"/>
	Fixture lamps			<input type="checkbox"/>
Comments				

PRILIMINARY PROGRAMMING CONSIDERATIONS

Project Name:		Project Number:
Mechanical Systems		
	Distributed mechanical equipment integrated into packaged roof-top equipment	<input type="checkbox"/>
	Central mechanical equipment served by boilers and chillers	<input type="checkbox"/>
	Hot and Chilled water distribution	<input type="checkbox"/>
	Special Use – HVAC requirements	
	Computer Server room	<input type="checkbox"/>
	Telecommunication and electronics rooms	<input type="checkbox"/>
	Art Gallery	<input type="checkbox"/>
	Laboratorium	<input type="checkbox"/>
	Kitchens	<input type="checkbox"/>
	Gymnasiums	<input type="checkbox"/>
	Others	<input type="checkbox"/>
	Maintenance Issues	<input type="checkbox"/>
	Availability and Life Expectancy	<input type="checkbox"/>
Comments		
Ventilation		
	Mechanical	<input type="checkbox"/>
	Natural	<input type="checkbox"/>
	Hybrid Systems	<input type="checkbox"/>
	High Occupancy Areas	<input type="checkbox"/>
	On-Demand	<input type="checkbox"/>
Comments		

APPENDIX D

Building Energy Efficiency Level 2 & 3 ECM Checklist

Instructions

The ECM Checklist makes it easier to track ECMs through the analysis process. The energy analyst submits the ECM Checklist two weeks before the scoping meeting. ECMs may be added to the checklist.

An example of an ECM listing follows:

Status Code	ID	Potential ECMs
B A N/A	E111	Add ceiling/roof insulation

Status codes indicate the phase of analysis or recommendation for each ECM. Check the boxes under the appropriate status code as the analysis progresses. Codes include:

- B Baseline. The ECM is included in the building baseline design.
- A Analyzed. The ECM is selected for analysis at the scoping meeting.
- N/A Not applicable.

The ID code includes a category letter and a three-digit number. “R” listed at end of three-digit number indicates ECM is primarily applicable to renovation projects.

Put an “X” under the appropriate code for each ECM.

B = Baseline
A = Analyzed
N/A = Not Applicable

STATE ENERGY EFFICIENCY DESIGN						
ENERGY Conservation Measures						
Project Name:					Project Number:	
E100-Envelope			ECM			
Status Code						
B	A	N/A	#	Potential ECM's	ECM Description	
			E110	Reduce Heat Losses		
			E111	Ceiling/roof insulation		
			E112	Wall insulation		
			E113	Floor/slab insulation		
			E114	Fan penthouse insulation		
			E115	Windows:		
			A	Thermal break in metal window frames		
			B	Wood, vinyl, or fiberglass window frames		
			C	Argon gas-filled glazing panels		
			D	High-performance low-e (e = 0.05) coating		
			E	Tinted glazing or reflective coatings		
			E120	Reduce Heat Gain		
			E121	Architectural shading and overhangs		
			E122	Window sizing and orientation		
			E123	Cool roof, green roof		
			E130	Reduce Infiltration		
			E131	Seal openings at penetrations of building envelope		
			E132	Air-lock vestibule or revolving doors		
			E190	Other Envelope Measures		

L100-Lighting					
Status Code					
B	A	N/A	ECM#	Potential ECM's	ECM Description
			L110	Efficient Lighting Systems	
			L111	Optimize fixture layout, spacing & orientation	
			L112R	Delamp overlit areas	
			L113	Efficient Fixture Selection, (fixture CU)	
			L114	Optimize Ballast Selection	
			L115	Efficient Lamp Selection	
			A	Compact fluorescents in place of incandescents	
			B	Incandescent IR Halogen vs standard PAR lamps	
			C	Ceramic Metal Halide vs standard PAR lamps	
			D	High-output linear fluorescents in place of HID fixtures	
			E	Pulse Start Metal Halides vs standard Metal Halides	
			F	LED technology, exit signs and other applications	
			L116	Exterior LPD at or below ASHRAE-90.1-2004	
			L120	Lighting Controls	
			L121	Occupancy sensors (exceeding code requirements)	
			L122	Selective switching, (control of multiple lamps within fixture)	
			L123	Egress lighting scheduled off during unoccupied periods	
			L124	Exterior lighting controls (exterior lights extinguished after occupied period (i.e. 9PM - 5AM)	
			L130	Optimize Daylighting	
			L131	Continuous dimming controls	
			L132	On/off daylighting control	
			L133	Separate circuits for zoning flexibility in daylit zones	

			L190	Other Lighting Measures	
W100 DHW					
Status Code					
B	A	N/A	W110	Reduce DHW Distribution Losses	
			W111	Install return-line aquastat (not required by code)	
			W120	Efficient DHW Generation	
			W121	90%-plus condensing hot water heaters	
			W122	Summer water heater or small boiler	
			W123	Preheat DHW with reclaimed waste heat (i.e. chiller condenser, direct-contact boiler stack economizer, 24/7 computer server room (AC unit)	
			W124	Solar-assisted water heater	
			W125	Heat pump water heater	
			W130	Process Related DHW Use	
			W131	Institutional laundry water reuse system	
			W132	Horizontal axis washing machines	
			W140	Heat Recovery	
			W141	Waste water heat recovery, i.e.GFX system	
			W190	Other DHW Measures	
F100-HVAC					
Status Code					
B	A	N/A	ECM#	Potential ECM's	ECM Description
			F110	Unitary Equipment	
			F111	Condensing furnaces	

			F112	Cooling-unit efficiency	
			F113	Air-to air heat pump efficiency	
			F114	Water-source heat pump	
			F115	Radiant heating	
			F116	Other HVAC general/unitary measures	
A100 HVAC - Air Distribution					
B	A	N/A	ECM#	Potential ECM's	ECM Description
			A110	Reduce Airflow Rates	
			A111	Variable airflow with VFD	
			A112	Cold air distribution	
			A120	Reduce Fan Pressure Resistance	
			A121	Minimize fan unit static pressure-losses: air filters, cooling and heating coils, enlarge cabinet size.	
			A122	Minimize duct static pressure-losses: enlarging ducting & optimize fittings	
			A130	Reduce Ventilation Loads	
			A131	Separate make-up air units for high-ventilation areas	
			A132	Heat recovery (air-to- air, run-around loop, heat wheel)	
			A140	Reduce Air Leaks and Heat Losses	
			A141	Install low-leakage dampers	
			A150	Fan Systems and Delivery Systems	
			A151	Specify efficient fans and select efficient size fan wheel	
			A152	Separate HVAC units for perimeter and core zones	
			A153 R	Change constant air-volume reheat to VAV reheat	
			A154 R	Change multi-zone or dual duct to VAV	
			A155	Parallel fan power VAV boxes to reduce perimeter zone reheat	
			A190	Other HVAC - Air Distribution ECMs	

D100 HVAC - Steam and Water Distribution					
Status Code			ECM#	Potential ECM's	ECM Description
B	A	N/A			
			D110	Reduce Energy Losses	
			D111	Steam trap monitoring and repair program	
			D112	Insulate piping and valve bodies	
			D120	Reduce System Flow and Pressure Resistance	
			D121	Variable primary pumping with VFD	
			D122	Increase cooling coil temperature difference	
			D123	Increase Heating coil temperature difference	
			D124	Reduce pump head pressure	
			D190	Other Steam or Water Distribution System	
T100 HVAC Controls					
Status Code			ECM#	Potential ECM's	ECM Description
B	A	N/A			
			T110	Air-Side Control Strategy	
			T111	Airflow and temperature setback in unoccupied areas through occupancy sensors or schedules	
			T112	Variable ventilation based on CO2 control	
			T113	Night-flush cooling cycle	
			T120	Water Side Control Strategy	
			T121	Time clock and OSA lockout control of heating and cooling pumps	

			T130	Misc. Controls	
			T131	Isolate large sheddable loads and install automated controls to limit electrical demand	
			T190	Other HVAC Controls	
C100 Cooling Plant					
Status Code			ECM#	Potential ECM's	ECM Description
B	A	N/A			
			C110	More Efficient Cooling Equipment	
			C111	Select efficient kW/ton chillers: 1) centrifugal, 2) screw, 3) reciprocating	
			C112	Select chiller size(s) for efficient sequencing	
			C113	Optimization of chiller sequencing controls	
			C114	Central Heat Pump	
			C120	Alternate Cooling	
			C121	Water-side free cooling: cooling tower and P&F heat exchanger	
			C122	Heat recovery chiller	
			C130	Increase Condenser Efficiency	
			C131	Specify more efficient cooling tower to reduce LWT	
			C132	Water-cooled versus air cooled	
			C133	Evaporative-cooled versus air cooled	
			C134	Condenser water reset controls	
			C190	Other Cooling Plant Measures	

H100 Heating Plant					
Status Code			ECM#	Potential ECM's	ECM Description
B	A	N/A			
			H110	Improve Boiler Efficiency	
			H111	Specify efficient boilers	
			H112	Select boiler size(s) for efficient sequencing	
			H113	Optimization of boiler sequencing controls	
			H114	Modulating burner control, specify high turn-down ratio (>5:1)	
			H115	Improve draft controls: turbulators, barometric dampers	
			H116R	Improve combustion by reducing excess air with O2 trim controls	
			H117	Boiler flue heat recovery to preheat combustion air or feed water	
			H118R	Recover heat from boiler blow-down	
			H120	Alternate Heating Systems	
			H121	Condensing hydronic boiler, design at lower supply/return water temp.	
			H122	Water-source or ground-source heat pumps	
			H190	Other Heating Plant Measures	
K100 Hoods and Make-up Systems					
Status Code			ECM#	Potential ECM's	ECM Description
B	A	N/A			
			K110	Kitchens, Labs, Shops, Process Equipment, etc.	
			K111	Minimize exhaust hood airflows, i.e. low flow hoods	
			K112	Minimize exhaust hood run time	
			K113	Separate make-up air unit set at lower temperature	

			K190	Other Hood and Make-up Systems	
S100 Swimming Pools					
Status Code			ECM#	Potential ECM's	ECM Description
B	A	N/A			
			S110	Pool Recovery and Controls	
			S111	Elevate air temperature to reduce pool evaporation rates	
			S112	Air-to-air heat recovery of ventilation air	
			S113	De-humidification heat recovery	
			S114	Variable ventilation based on advanced climate controls sensing humidity, indoor/outdoor/dew-point temperatures	
			S115	Lower ventilation rates during unoccupied hours	
			S116	Low pressure-drop pool water filters/strainers	
			S117	Two-speed circulation/filtration pumping (occupied/unoccupied modes)	
			S190	Other Swimming Pool Measures	
P100 Power/Electrical Distribution					
Status Code			ECM#	Potential ECM's	ECM Description
B	A	N/A			
			P110	Premium-efficiency motors	
			P111	In excess of code (Consortium for Energy Efficiency) i.e.fans, pumps, etc.	
			P120	Vertical Transport	
			P121	Hydraulic elevator pump/motor efficiency opportunities	
			P122	Traction Elevator	
			P130	Server and Telecom Rooms	

			P131	Multiple small compressors for efficiency and redundancy	
			P132	Air side economizer cooling	
			P133	Water side economizer cooling	
			P134	Wider deadband for humidity and temperature control (based on actual design requirements)	
			P140	Refrigeration Systems	
			P141	Select units with high efficiency compressors	
			P142	Increase condensing efficiency and optimize capacity control	
			P143	Install floating-head pressure controls	
			P150	Appliances	
			P151	Residential Energy Star- refrigerator, dishwashers, washing machines, etc	
			P152	Commercial Equipment- Pcs, LCD Monitors, copiers, vending	
			P190	Other Power Measures	

APPENDIX E

ENERGY ANALYSIS REPORT FORMAT

The Energy Analyst completes the *Energy Analysis Report* according to the following outline. The report includes previously submitted data, such as the building description and building design criteria. Present the data in a bound report in the order described and with all tables shown. Include the energy model electronic input/output files in an attached sleeve within the report.

I. Section 1. Executive Summary

- a. Provide a brief description of the facility and the analysis process. Include for the Compliant Building and the Baseline Building, the following information; the energy use, energy cost, energy-use index (EUI), and energy-cost index (ECI). The EUI is Btu per conditioned square foot per year. The ECI is dollars per conditioned square foot per year.
- b. Include a table of analyzed package results (Table 1-1). This table shows ECM costs, annual cost savings, annual million Btu (MMBtu) savings, Net Present Value savings (NPV), Net Present Cost Savings (NPC), benefit-to-cost ratio (BCR), and percent energy savings as compared to the Code Building.

A. Table 1-1 – ECM Package Analysis Summary						
Recommended Package						
Incremental Investment Cost	Annual Dollar Savings	Annual MMBtu Savings	NPV Savings	NPC Savings	Benefit-To-Cost Ratio	% Energy Use Below Code Bldg.
Instructions for Table 1-1: Summarize package results from Tables 3-1. Percent below code is based on the Code Building. All other values are as compared to the Proposed Baseline Building.						

- c. Provide brief description of recommended ECMs and ECM package.
- d. Describe other results.
- e. Include a list of all considered ECMs grouped by status: recommended package, individually cost effective, individually not cost effective, or included in baseline.

Section 2. Baseline Building

- a. Provide detailed building descriptions. Include the following:
- **Building Operating Characteristics.** Discuss building operation, function, site, and occupancy schedule.
 - **Building Envelope Characteristics.** Discuss construction and thermal properties of all exterior envelope components. Include window thermal performance, frame materials, window to wall ratios, and building and window shading surfaces.
 - **Lighting and Lighting Controls.** Discuss target footcandle levels, lighting power densities, lamp and fixture types, operating schedules, lighting controls (i.e. sweep, occupancy sensors, daylight dimming, etc.)
 - **Exterior lighting and controls.** Discuss lamp and fixture type, operating schedules, and controls.
 - **HVAC Systems.** Describe type and characteristics of the HVAC systems in the building and the areas served by each system. Include capacities of heating and cooling units, efficiencies of units, list fan/pump motor sizes, ventilation quantities, supply and exhaust air volumes, etc. Describe boilers, chillers, cooling towers, heating and chilled water loops, heat exchangers, and other central plant equipment.
 - **Describe HVAC controls system and controls strategies.** Include temperature set points, operating schedules, etc.
 - **Domestic Hot Water.** Discuss hot water using equipment. Describe capacities, efficiencies, fixture flow rates, circulation pumps and schedules.
 - **Miscellaneous and Process Equipment.** Discuss other energy using equipment including miscellaneous plug loads, kitchen equipment, laundry equipment, computer room equipment, process loads, etc.
- b. List each Baseline ECM, (Table 2-1). Baseline ECMs are those ECMs that are included in the Proposed Baseline Building without the need for detailed cost effectiveness analysis.

<i>B. Table 2-1 Baseline ECMs</i>	
ECM No.	ECM Name
Instructions for Table 2-1: List Baseline ECMs.	

- c. Provide detailed descriptions of baseline ECMs. The description should contain the level of detail necessary to serve as a performance specification for the design team so they can design an ECM that achieves the projected savings and specific enough for the commissioning agent, or other performance verification provider to verify in the construction documents. An example is a daylight dimming system. The required information would include areas where this ECM would be implemented, identification of controlled fixtures, fixture control strategy, required foot-candle levels, and any architectural features related to this measure such as lightshelves, overhangs, blinds or shades, window configuration, and glazing visible light transmittance.
- d. Describe building energy analysis. Discuss energy analysis program used, modeling assumptions, and parameters.
- e. Discuss utility rates.

- f. Discuss modeling results. Include comparison to similar building types or comparison to utility bills if modeling an existing building.
- g. Include a table of annual Proposed Baseline energy use and cost by category (Table 2-2). Indicate the energy rates used and determine the energy-use index (EUI) and energy-cost index (ECI).

Table 2-2 – Proposed Baseline Building Energy Use Summary						
Energy Use Category	MMBtu per Year			% of Total MMBtu	Annual Energy Cost	% of Total Cost
	Electricity	Natural Gas*	Total			
Heating						
Cooling						
Fans/Pumps						
Lighting						
Dom. Hot Water						
Equip. & Misc.						
Total				100%		100%
Gross conditioned** Floor area in square feet		Energy Use Index (EUI) Btu per square foot per year		Energy Cost Index (ECI) \$ per square foot per year		
Electricity cost per kWh***:			Natural gas cost per therm***:			
Table 2-2 Instructions. Using the results from the baseline energy model, list the energy use by fuel type and total cost for each end use category. Calculate and show the energy-use index (Btu per gross conditioned square foot) and energy-cost index \$ per gross conditioned square foot).						

*Substitute oil or other fuel for natural gas, if appropriate.

**The gross conditioned floor area is the heated or cooled part of the building measured to the outside of the walls.

*** If utility rate include seasonal charges, block charges, demand charges, etc, use average annual rate.

II. Section 3. Preliminary ECM Analysis

Section 3 of the *Energy Analysis Report* is based on individual analysis of ECMs and of the recommended ECM package before the ECM review meeting. ECM content and results may change as a result of the ECM review meeting. Refer to Section 5 of the *Energy Analysis Report Format* for final results and descriptions.

- a. Provide detailed descriptions of cost-effective ECMs and discuss implementation and feasibility considerations. Describe ECM components, and how the measure saves energy. Schematic level drawings are encouraged. The description should contain the level of detail necessary to serve as a performance specification for the design team so they can design an ECM that achieves the projected savings and specific enough for the commissioning agent, or other performance verification provider to verify in the construction documents.. Describe the areas affected by each ECM. An example would be a dedicated ventilation system with heat recovery. The description would include the specifics of the system including suggested location, areas served, airflow, heating source and efficiency, heat recovery technology and efficiency, control strategies, and effect on remaining other systems.
- b. Describe analyzed ECMs determined not to be cost-effective. Less detail is required for the descriptions of these ECMs
- c. Provide a table that shows ECM results based on preliminary analysis (Table 3-1). Include the first-year energy savings and costs for the analyzed ECMs.
 - The Energy Analyst calculates savings using the building model. Savings are calculated using the Proposed Baseline as the benchmark. Savings are expressed in MMBtu for all fuel types to allow comparison of fuels.
 - The first-year energy cost savings is the annual energy savings based on current energy rates.
 - The incremental investment cost is the increase in ECM cost compared with the Proposed baseline. It is the budget cost increase required for ECM implementation.
 - Enter the BCR that summarizes individual Analyzed ECM results based on life-cycle cost analysis. The benefit-to-cost ratio (BCR) is the PV of the savings (benefit) divided by the PV of the costs. The BCR must be greater than one (1.0) for a measure to be considered cost effective.
 - Create an interactive model that includes all analyzed ECMs with a BCR greater than 1.

A. Table 3-1 Preliminary ECM Savings Analysis

ECM No		Energy Savings per Year			Annual (\$) Savings	Incremental Investment Cost (\$)	Benefit to Cost Ratio
		Electricity	Natural Gas*	Total			
Individually Cost-Effective ECMs							
Interactive Package (Recommended Baseline Bldg)							
% Savings							N/A
Other Analyzed ECMs (not cost-effective)							
Table 3-1 Instructions. The values in Table 3-1 represent first-year results shown on the <i>Preliminary ECM Cost-Effectiveness Analysis</i> worksheets (Appendix J of the Guidelines). Items are as follows: <ul style="list-style-type: none"> • Annual Energy Savings section: Enter for each fuel and the total. • Annual \$ Saved: Total Annual Savings (Energy + Maintenance). • Incremental Investment Cost: Cost from the ECM Incremental Capital Cost section. • The Benefit to Cost Ratio represents the results of the Preliminary ECM Cost-Effectiveness • Percent Savings based on comparison to baseline building use from Table 2-2. 							

*Substitute oil or other fuel for natural gas, if appropriate.

Section 4. Compliant Building

- a. Provide a description of the differences between the Recommended Baseline Building and the Compliant Building.
- b. List any ECMs included in the Baseline Building which is recommended for removed from the Compliant Building.
- c. Include a table of annual Compliant Building energy use and cost by category (Table 4-1). Indicate the energy rates used and determine the energy-use index (EUI) and energy-cost index (ECI).

Table 4-1 – Code Building Energy Use Summary						
Energy Use Category	MMBtu per Year			% of Total MMBtu	Annual Energy Cost	% of Total Cost
	Electricity	Natural Gas*	Total			
Heating						
Cooling						
Fans/Pumps						
Lighting						
Dom. Hot Water						
Equip. & Misc.						
Total				100%		100%
Gross conditioned** floor area in square feet		Energy Use Index (EUI) Btu per square foot per year		Energy Cost Index (ECI) \$ per square foot per year		
Electricity cost per kWh:			Natural gas cost per therm:			
Table 4-1 Instructions. Using the results from the Code energy model, list the energy use by fuel type and total cost for each end use category. Calculate and show the energy-use index (Btu per gross conditioned square foot) and energy-cost index (\$ per gross conditioned square foot).						

*Substitute oil or other fuel for natural gas, if appropriate.

**The gross conditioned floor area is the heated or cooled part of the building measured to the outside of the walls.

- d. Compare Baseline Building Energy Use to Compliant Building.

B. Table 4-2– Recommended Compliant Building Savings Compared to Baseline Building

	ECMs Included in Package (by number)	Energy Use MMBtu		Energy Savings MMBtu	% Energy Savings
		Electricity	Natural Gas*		
Code Building	N/A			N/A	N/A
SEED Building					

Table 4-2 Instructions. The values in Table 4-2 represent the first-year energy savings. Items are as follows:

- Recommended SEED Energy Use and Code Building from Tables 3-1 and 4-1.
- Energy savings and % energy savings are calculated values.

Section 5. Final ECM Package Analysis (completed after ECM review meeting)

Section 5 of the *Energy Analysis Report* describes any differences between the recommended ECM package and the final SEED package from Section 3.

- Discuss the recommended ECM package at the ECM review meeting. **Document agency comments and any reasons for eliminating cost-effective ECMs. Document any changes to ECMs or baseline assumptions.**
- Update any changes to the previous Sections of the report based on feedback received at the ECM review meeting, Revise Table 3-1 to show the final ECM Package (SEED Building) results and Table 4-2 to show percentage better than code building, if this has changed.
- Describe the recommended ECM package and discuss implementation and feasibility considerations.
- Include a table of annual SEED Building energy use and cost by category (Table 5-1). Indicate the energy rates used and determine the energy-use index (EUI) and energy-cost index (ECI).

Table 5-1 – SEED Building Energy Use Summary						
Energy Use Category	MMBtu per Year			% of Total MMBtu	Annual Energy Cost	% of Total Cost
	Electricity	Natural Gas*	Total			
Heating						
Cooling						
Fans/Pumps						
Lighting						
Dom. Hot Water						
Equip. & Misc.						
Total				100%		100%
Gross conditioned** floor area in square feet		Energy Use Index (EUI) Btu per square foot per year		Energy Cost Index (ECI) \$ per square foot per year		
Electricity cost per kWh:			Natural gas cost per therm:			
Table 5-1 Instructions. Using the results from the SEED energy model, list the energy use by fuel type and total cost for each end use category. Calculate and show the energy-use index (Btu per gross conditioned square foot) and energy-cost index \$ per gross conditioned square foot).						

- Discuss any other results determined during the analysis. Present the financial impact of other items reviewed that are not ECMs.

REPORT APPENDIX

The Energy Analyst includes the following appendices in the *Energy Analysis Report*.

1. Baseline-model HVAC zone map.
2. Model inputs for the Compliant Building, and the Baseline Building. Electronic copies of inputs and the complete output reports are required.
3. Provide a table that lists the modeling inputs and values that have been changed for each building model.
4. Summary output report(s) for the Compliant Building and the Baseline Building:
 - A breakdown of energy usage by at least the following components: lights, internal equipment loads, service water heating equipment, space heating equipment, space cooling and heat rejection equipment, fans, and other HVAC equipment (such as pumps).
 - The amount of time any loads are not met by the HVAC system for both the SEED building design and baseline building design
 - An explanation of any warning messages noted in the simulation program output.
5. Manual savings calculations if any.
6. ECM calculations, estimates, and justification for eliminated ECMs, including *Cost Effectiveness Analysis* worksheets for all eliminated ECMs.
7. Cost estimates for all ECMs analyzed
8. *Cost-Effectiveness Analysis* worksheets (See Appendix J)
 - Individual ECMs analyzed
 - ECM packages
9. Current energy rate schedules. Where energy is received from a state-operated central plant, cite the rate source used.
10. Meeting minutes:
 - Scoping meeting
 - ECM review meeting including an updated ECM checklist showing Recommended ECMs.
11. Miscellaneous information: equipment catalog sheets, equipment rated performance., i.e. ARI, ANSI, NFRC , etc.
12. Energy Systems Performance Verification Plan (See Appendix E for plan details)
13. Building Metering Plan (See Appendix F for metering requirements)